Appendix F: Resource Equivalency Analysis

Background

There are two basic approaches to measuring the value of natural resources. One is to focus on the demand side, the "consumer valuation approach"; the other is to focus on the supply side, the "replacement cost" approach. In the former, we seek to measure the monetary value that the public puts on the natural resources (i.e., how much the public demands the services of natural resources); in the latter, we seek to measure how much it costs to replace the natural resources if they are injured (i.e., how much it costs to supply natural resource services). See the Glossary for complete definitions of some of the terms used here.

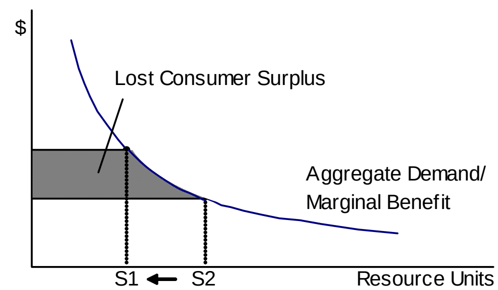

FIGURE 1: Consumer Valuation Approach

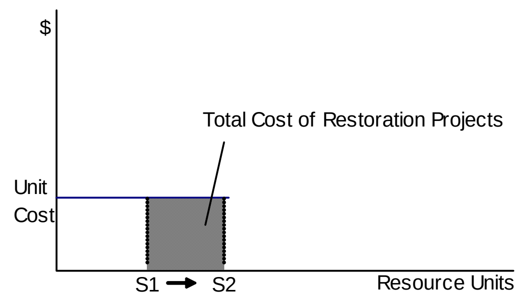

FIGURE 2: Replacement Cost Approach

Figures 1 and 2 illustrate the difference between these two approaches. In both figures, the supply of natural resources shifts from S1 to S2 as a result of an incident (e.g., oil spill, sediment discharge into a stream, illegal removal of vegetation). Figure 1 illustrates the loss of consumer surplus resulting from this decrease in natural resources. However, because there are no observable market prices, the demand curve and our relative location on the vertical axis (how much the public values the resource) are difficult to measure. Contingent Valuation (CV) and other types of analyses are designed to measure the lost consumer surplus. These methodologies typically involve large surveys and can be costly.

Figure 2 illustrates a simple replacement cost approach. In this case, the demand of the public for the resource and how much the public values the resource are not considered. Instead, the resource is valued according to the cost of replacing it. Resource Equivalency Analysis (REA) is the primary methodology for this type of measurement. Note that the cost of restoring habitat (labeled "cost" on the vertical axis) is not necessarily correlated with the public's valuation of the resource, nor is the lost consumer surplus (the shaded area in Figure 1) necessarily equal to the total replacement cost (the shaded area in Figure 2). This is especially true when unique resources or rare species are involved, as the public demand for them may be much more inelastic (i.e. a more vertical demand curve; the public demand is more fixed and less a function of price), resulting in a much larger loss of consumer surplus. In such a case, the replacement cost approach of REA may result in damages far less than the losses as valued by the public. However, because it is easier and less costly to measure the total replacement cost than the lost consumer surplus, REA has an advantage over other methods, especially for small to medium-sized incidents with minimal impact on rare species.

Resource Equivalency Analysis

We have employed REA as the method of determining compensatory damages. This method is relatively inexpensive and relies primarily on biological information collected in the course of determining natural resource injuries caused by the spill. It also avoids putting a direct dollar figure on the consumer surplus of the resource, relying instead on restoration-based service-to-service compensation. This is consistent with approaches recommended in the language of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Oil Pollution Act of 1990 (OPA).

REA involves determining the amount of “natural resource services” that the affected resources would have provided had it not been injured, and it equates the quantity of lost services with those created by proposed compensatory restoration projects that would provide similar services. The unit of measure may be acre years, stream feet years, or some other metric. The size of the restoration project is scaled to the injury first; the cost of restoration is then calculated after the scaling has been done. The cost of restoring a comparable amount of resources to those lost or injured is the basis for the compensatory damages. In this sense, REA calculates the *replacement cost* of the lost years of natural resource services.

Future years are discounted at 3% per year, consistent with NOAA recommendations for natural resource damage assessments. Discounting of future years is done based on the assumption that present services are more valuable than future services. When it comes to natural resources, the question of whether or not society should value the present more than future is a philosophical question (e.g., one can recall the “greenhouse effect” and the question of how much expense we should incur today to preserve the future). However, the question of how much society actually discounts the value of future natural resources is an empirical one. The 3% figure is currently the standard accepted discount rate for natural resource damage assessments.

REA involves three steps: 1) the debit calculation, 2) the credit calculation, 3) the computation of the costs of restoration. These calculations may be done in a variety of ways, but the most common are to estimate the injury and the restoration benefits in terms of area years of habitat or animal years.

Habitat Example

For example, suppose a 10 acre area is degraded due to an oil spill such that it supplies only 30% of its previous habitat services during the year following the incident. In the second year after the incident, the habitat begins to recover, supplying 90% of its baseline services. By the third year it is fully recovered. In this case, the lost acre years of habitat services would be 70% x 10 acres x 1 year + 10% x 10 acres x 1 year = 8 acre years of habitat services. Figure 3 (next page) illustrates this example by showing the recovery path of the habitat over time.

As stated above, future years are discounted at a 3% rate, thus the injuries in the second year count a little less. Incorporating this, 7.97 acre years of habitat services were lost. This difference appears minimal here, but becomes significant (due to compounding) if injuries persist many years into the future.

The credit calculation focuses on the gain in habitat services that result from a restoration project. Creating acre years of habitat services is a function of both area and time.

Hypothetically, compensation could involve taking 7.97 acres of land with no habitat value (e.g., a parking lot) and turning it into productive habitat for 1 year. Alternatively, we could achieve compensation by creating 1 acre for 7.97 years. In reality, most restoration projects involve taking previously degraded habitat (at another nearby location) and restoring it over a number of years, and maintaining it into the future.

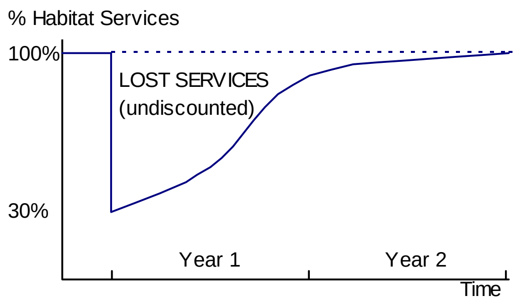

FIGURE 3: Biological Injury and Recovery

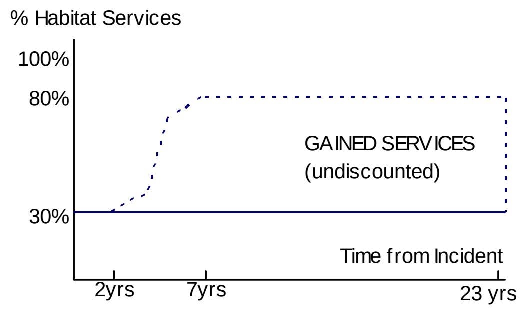

FIGURE 4: Restoration Trajectory/Credit

Suppose the restoration project improves the quality of a nearby degraded area, so that, if it previously provided only 30% of potential services, it would provide 80% of potential habitat services after restoration. Also suppose the project begins two years after the incident and it takes an additional 5 years for the 80% level to be achieved. Figure 4 provides an illustration of this restoration trajectory. In our hypothetical example, the project is expected to have a lifespan of 20 years. Note that, with future years discounted, the 20th year of the project (22-23 years after the incident) counts little; years after that are effectively completely discounted due to uncertainty regarding the future.

Mathematically, we seek to restore an area that will provide 7.97 acre years of services over the discounted 20-year phased-in life span of the restoration project. In this example, that would be an area of about 1.3 acres. That is to say, restoration of 1.3 acres for 20 years would compensate the public for the 7.96 lost acre years of habitat services due to the spill. Visually, the area identified in Figure 3 (multiplied by the affected acres and calculated to measure the present discounted value) should equal the area identified in Figure 4 (again, multiplied by the acres targeted for restoration and calculated to measure the present discounted value, thus discounting future years).

The percentage of habitat services lost (or gained, in the case of the restoration project) may be measured in a variety of ways. For our hypothetical oil spill case, three examples might include (1) the use of a habitat-wide evaluation index, (2) the use of one or more surrogate species, or (3) the use of an estimate based on the degree of oiling. Care must be taken when using a surrogate species to represent the entire affected habitat. Ideally, this surrogate is the population of one or more species that is immobile (that is, the animals do not move easily in and out of the affected area) and that has significant forward and/or backward ecological links to other species in the affected ecosystem. For example, the population of red crossbills, a bird that feeds primarily on pine cone seeds and migrates erratically from year to year, would be a poor surrogate for measuring injuries to a streambed. The aquatic macroinvertebrate community within the stream, however, provides an ideal surrogate, as they play a key role in the streambed food chain. Likewise, on the restoration side, care must taken when the project targets one or a few species rather than the entire habitat. Ideally, a project that seeks to restore the population of a key indicator species will also benefit the entire habitat and, thus, other species as well. Indeed, such projects typically focus directly on habitat improvements. However, it is important to verify that such a species-centered project is indeed benefiting the entire habitat.

Animal Example

When the injury is primarily to individual animals rather than a complete habitat, the REA may focus on lost animal years. For example, suppose an oil spill causes negligible injury to a body of water, but results in the death of 100 ducks. Using information about the life history of the ducks (e.g., annual survival rate, average life expectancy, average fledging rate, etc.), we can estimate the “lost duck years” due to the spill. On the credit side, we can examine restoration projects designed to create duck nesting habitat and scale the size of the project such that it creates as many duck years as were lost in the incident.

Restoration Costs = Natural Resource Damages

Once the proposed restoration projects are scaled such that they will provide services equal to the those lost due to the incident, the cost of the projects can be calculated. Note that this is the first time dollar figures enter the REA process. Until now, all the calculations of the “equivalency” have been in terms of years of resource services. The cost of the restoration projects is the compensatory damage of the incident.

Prepared by:
Steve Hampton, Ph.D.
Resource Economist
California Department of Fish and Game
(916) 323-4724
shampton@ospr.dfg.ca.gov

Revised by:
Matthew Zafonte, Ph.D. and Steve Hampton, Ph.D.
Revision Date: May 29, 2002

For another explanation of the REA methodology (in its more specific form for habitats), see “Habitat Equivalency Analysis: An Overview”, prepared by NOAA. Copies of this document are available at http://www.darp.noaa.gov/publicat.htm

GLOSSARY

Aggregate demand

the demand of all consumers combined; e.g., if there are 20,000 people in a town and each person demands two pieces of bread each day, the aggregate demand is 40,000 pieces of bread per day.

Consumer surplus

the difference between the total value consumers receive from the consumption of a particular good and the total amount they pay for the good; e.g., a person may value that first Coke (on a hot day) at $2.00, but is only willing to pay $1.00 for a second one, and a third one would only be worth 25 cents to them. If a Coke costs 70 cents, they would buy two. They would spend $1.40 on the two Cokes, but receive $3.00 in value. Thus, their consumer surplus (kind of like “profit” for the consumer) would be $1.60.

Compensatory restoration

a restoration project which seeks to compensate the public for temporal or permanent injuries to natural resources; e.g., if a marsh is injured by an oil spill and recovers slowly over ten years, a compensatory project (which may be off site) seeks to compensate the public for the ten years of diminished natural resources.

Discount rate

the rate at which the future is discounted, i.e., the rate at which the future does not count as much as the present; e.g., a dollar a year from now is worth less than a dollar today; if the bank offers a 3% rate, whereby $1.00 becomes $1.03 in one year, the future was discounted at 3%.

Primary restoration

a restoration project which seeks to help an injured area recover more quickly from an injury; e.g., if a marsh is injured by an oil spill and would recover slowly over ten years if left alone, a primary restoration project might seek to speed the recovery time of the marsh and achieve full recovery after five years.

Replacement cost

the cost of replacing that which was lost; e.g., if fifty acre-years of habitat services were lost due to an oil spill, the cost of creating fifty acre-years of similar habitat services would be the replacement cost.